Emma Preuschl  
Friday Morning Lab  
Dr. James Daniels

Blameless Brownies: Investigating the replacement of fats in commercially prepared brownies

Abstract
The purpose of this experiment is to use the consumer friendly boxed brownies and replace the fat content of the brownies by using synthetic oils. The recipe can potentially offer more nutrients and less cholesterol and saturate fat. The baking properties of the brownies are measured in three separate trials. Three trials were done for this experiment and in each trial the texture of the brownies was analyzed, water activity levels recorded and, a sensory panel taste tested the brownies to compare moistness and flavor of the brownies. 4 different types of oils were used; the control group-vegetable oil, grape seed oil, Enova oil, and flax seed oil. The control variable was favored by the sensory panel but the panel preferred grape seed oil when they were compared to one another. When Sample 312, made with vegetable oil was compared with Enova Oil only 9% of the sensory panel could taste the difference between the two. When the panel tasted sample 213 and then tasted flaxseed oil brownies 68% preferred control brownies made with vegetable oil. The flaxseed brownies were the least desired product overall. They had a “fish aftertaste” and were chewier then the other variables. The vegetable oil was the moistest product in all three trials and the average grams of force needed for these brownies was 56.8 g. when compared to the tough texture of the Enova oil and the flax seed oil which both took over 75.0 grams of force to slice. The water activity levels of the 4 variables ranged between 0.676 – 0.856 Aw. There was little difference between the variables implies that substituting oils does not affect the water activity levels of the brownies. Using Enova oil and grape seed oil as replacement ingredients in commercial brownies will change the texture of the brownie but not affect greatly effect the final flavor.
I. Introduction

Cooking oils used today contain saturated, monounsaturated, and polyunsaturated fatty acids. The food industry uses fats and oils to give foods flavor, consistency, and stability. Fats are great source of energy and they oxidize faster then other nutrients because they have less amounts of oxygen. In this experiment, the oxidative rancidity, water activity levels, and flavor components of cooking oils in brownies will be measured.

The chemical process of oxidation occurs when the “cis” double bonds of mono and polyunsaturated fats are broken down by exposure to oxygen. When they are broken down it produces compounds that make the oil rancid and causes the products to taste sour and bitter. There are products in the food industry such as hydrogenated vegetable oil that are used to control rancidity and extend shelf life of products. Hydrogenation is a chemical process that adds hydrogen to the available double bonds in the vegetable oil. As the degree of hydrogenation increases, the amount of saturated fat increases and mono and polyunsaturated fat decreases. The liquid fats become solids and the “cis” double bonds become “trans” fatty acids but there are no trans fatty acids in this experiment. The brownies made in this experiment contain omega 3 and alpha linolenic fatty acids. They are primarily found in flax seed oil and are digested can be digested by the enzyme lipase. These are essential fatty acids found in oils such as vegetable oil, flaxseed oil, enova oil, and grape seed oil and when used in moderation have many health benefits. “…ω-3-linolenic acid, found in green leafy vegetables, flaxseed, rapeseed, and walnuts, desaturates and elongates in the human body to EDA and DHA and by itself may have beneficial effects in health and aid in the control of chronic diseases. (Simopoulos, 560S)”

The increased intake of Vitamin E is also being monitored through the sensory panel. Vitamin E is a fat-soluble vitamin and is highly concentrated in grape seed oil. Vitamin E acts as an antioxidant by neutralizing free radicals in the body that cause tissue and cellular damage.
Vitamin E is associated with a decreased risk of Coronary Artery Disease. It also decreases symptoms of premenstrual syndrome and some breast cancers. Vitamin E is an antioxidant which strongly prevents membrane peroxidation. Lipid peroxidation is defined as the oxidative deterioration of lipids that contain any carbon-carbon double bonds. To minimize lipid peroxidation essential fatty acid should be taken in with at least 500 mg of Vitamin E per day. Combining Vitamin E and omega-3 fatty acids is the best way to reduce the risk of cancer risk while protecting heart cell membranes, brain cell membranes, immune-cell membranes and the receptor membranes that allow hormones in the body to function. By substituting grape seed oil for vegetable oil in food products consumers can increase their vitamin E intake by 38%.

Enova™ oil is comprised mainly of Diacylglycerol (DAG); Enova™ oil consists of at least 80% DAGs. “Diacylglycerol (DAG) is a component of various vegetable oils. Approximately 70% of the DAG in edible oils are in the configuration of 1, 3-DAG. We recently showed that long-term ingestion of dietary oil containing mainly 1; 3-DAG reduces body fat accumulation in humans as compared to triacylglycerol (TAG) oil with a similar fatty acid composition. (Taguchi, 379)”

I will be using the Betty Crocker pre-packaged boxed brownies and replacing the vegetable oil with a series of reduced saturated fat oils; grape Seed oil, Enova Brand oil, and flax seed oil. Subjective taste panel was used to measure the flavor differences between the substitutions of the various cooking oils. The independent variables are the types of oils used in each variable and the dependent variable is the uncontrollable factor that is recorded by the texture analyzer in the grams of force needed to cut the brownie. Texture and analyzer and hydrometer will be used in the laboratory to measure the objective measurements. The experiment explores the changes in moisture and water activity levels that the brownies undergo during the baking process. Previous research published by the Nutrition Reviews claims “The
association between dietary fat and CHD has been extensively studied and diets high in saturated fatty acids and Trans fatty acids increase LDL cholesterol levels, and in turn, the risk of heart disease. (Lichtenstein, 3)"

II. Methods

- For each trial mix appropriate amounts of ingredients in appropriate mixing bowls.
- Measure in grams the calculated amounts of oil. Each variable uses a different oil and different ounces of that oil. (i.e. Grape seed oil variable only needs ½ the amount of the vegetable oil brownies.)
- Bake the brownies for 35 minutes or until the knife test works.
- Cool brownies completely and cut in even squares eliminating edge/crust pieces
- Use the texture analyzer and hydrometer in the food chemistry lab to obtain objective date for each variable. See below for specific details on how to use the machinery. (re: probes and settings.)
- Have a sensory panel of 6 or more people taste the brownies and complete the paired comparison sensory scorecard.

Variable 1, control variable, Sample # 312
1. Heat oven to 177 degrees C
2. Follow instructions included on the back of the box packaging.
3. Add 875 grams water, 96 ounces of vegetable oil, and 2 whole eggs. Mix brownie batter until slightly lumpy. Spread into a 13”x9” pan sprayed with canola oil cooking spray and bake for 35 minutes.

Variable 2, Grape Seed Oil Brownie, Sample # 754
1. Heat oven to 177 degrees C
2. Follow instructions included on the back of the box packaging.
3. Add 875 grams water, 48 ounces of Grape Seed oil, and 2 whole eggs. Mix brownie batter until slightly lumpy. Spread into a 13”x9” pan sprayed with canola oil cooking spray and bake for 35 minutes.

Variable 3, Enova™ Oil Brownie, # 207
1. Heat oven to 177 degrees C
2. Follow instructions included on the back of the box packaging.
3. Add 875 grams water, 96 ounces of Enova Brand Oil, and 2 whole eggs. Mix brownie batter until slightly lumpy. Spread into a 13”x9” pan sprayed with canola oil cooking spray and bake for 35 minutes.

Variable 4, Flax Seed Oil Brownie, # 876
1. Heat oven to 177 degrees C
2. Follow instructions included on the back of the box packaging.
3. Add 875 grams water, 96 ounces of Flax Seed Oil, and 2 whole eggs. Mix brownie batter until slightly lumpy. Spread into a 13”x9” pan sprayed with canola oil cooking spray and bake for 35 minutes.

- Complete Objective tests
  1. Use 1 inch cubed portions of all 4 variables in the texture analyzer.
  2. Use the cone probe on the texture analyzer for the test and the muffin setting for the 4 variables in each of the 3 trials.
3. Measure the water activity in the water activity machine.

- Set up a paired comparison test for a 10 person sensory board to evaluate subjectively.
  1. Sample # 312 (Control variable) vs. Sample #754 (Grape Seed)
  2. Sample #312 (Control Variable) vs. Sample # 207 (Enova)
  3. Sample # 312 (Control Variable) vs. Sample # 876 (Flax Seed)
  4. Sample # 754 (Grape Seed) vs. Sample #207 (Enova)
  5. Sample # 207 (Enova) vs. Sample 876 (Flax Seed)
  6. Sample # 754 (Flax Seed) vs. Sample # 876 (Grape Seed)
     a. Each food sample will be cut into 2”x 2” squares.
     b. Allow Brownies to completely cool before cutting into the pan. This could take up to 45 minutes. The cooling process will give a uniform atmosphere and temperature so that the texture analyzer data will not be affected by the temperature of the products.
     c. You can begin the objective and subjective tests after the brownies are cooled and cut evenly.
     d. A sample of the sensory scorecard is attached.

---

**SAMPLE SENSORY SCORECARD**

**BROWNIES: PAIRED COMPARISON TEST**

Emma Preuschl  
453 Individual Project

Judge: _________________________ Date: _____________________

Please taste each sample and circle the sample number you prefer for each pair.

<table>
<thead>
<tr>
<th>Sample #</th>
<th>Sample #</th>
<th>Which Sample # is the moister?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Pair A</td>
<td>754</td>
<td>312</td>
</tr>
<tr>
<td>2) Pair B</td>
<td>207</td>
<td>876</td>
</tr>
<tr>
<td>3) Pair C</td>
<td>312</td>
<td>876</td>
</tr>
<tr>
<td>4) Pair D</td>
<td>754</td>
<td>207</td>
</tr>
<tr>
<td>5) Pair E</td>
<td>312</td>
<td>876</td>
</tr>
<tr>
<td>6) Pair F</td>
<td>876</td>
<td>754</td>
</tr>
</tbody>
</table>

Comments on Sample #312:

Comments sample #876

Comments sample #754

Comments sample #207
III. Results

Experiment 1: Texture analyzed comparisons of vegetable oil, grape seed oil, Enova™ Oil, and flax seed oil for each of the three trials.

<table>
<thead>
<tr>
<th>Table 1. Texture Analyzer vs. Oil Replacers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
</tr>
<tr>
<td>Vegetable Oil</td>
</tr>
<tr>
<td>Grape Seed Oil</td>
</tr>
<tr>
<td>Enova Oil</td>
</tr>
<tr>
<td>Flaxseed Oil</td>
</tr>
</tbody>
</table>

![Figure 7. Blameless Brownies: Texture Analyzer vs. Oil Replacers](image)

Experiment 2: Water Activity levels comparisons of three trials

<table>
<thead>
<tr>
<th>Table 2. Water Activity vs. Oil Replacers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample</td>
</tr>
<tr>
<td>Vegetable Oil</td>
</tr>
<tr>
<td>Grape Seed Oil</td>
</tr>
<tr>
<td>Enova Oil</td>
</tr>
<tr>
<td>Flaxseed Oil</td>
</tr>
</tbody>
</table>
Experiment 3: Texture Analyzer vs. Water Activity in cooking oil for trial 1, trial 2, and trial 3.

**Table 9. Vegetable Oil Texture Analyzer vs. Water Activity**

<table>
<thead>
<tr>
<th>Aw</th>
<th>Vegetable Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.676</td>
<td>44.01</td>
</tr>
<tr>
<td>0.741</td>
<td>70.6</td>
</tr>
<tr>
<td>0.8</td>
<td>55.8</td>
</tr>
</tbody>
</table>

**Table 10. Flax Seed Oil Texture Analyzer vs. Water Activity**

<table>
<thead>
<tr>
<th>Aw</th>
<th>Flax Seed Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.7</td>
<td>77.11</td>
</tr>
<tr>
<td>0.73</td>
<td>92</td>
</tr>
<tr>
<td>0.821</td>
<td>50.7</td>
</tr>
</tbody>
</table>
### Table 11. Grape Seed Oil Texture Analyzer Vs. Water Activity

<table>
<thead>
<tr>
<th>Aw</th>
<th>Texture Analyzer-Grams of Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.747</td>
<td>33.76</td>
</tr>
<tr>
<td>0.729</td>
<td>92.9</td>
</tr>
<tr>
<td>0.856</td>
<td>65.6</td>
</tr>
</tbody>
</table>

**Figure 11. Grape Seed Oil: Texture Analyzer vs Water Activity**

### Table 12. Enova™ Oil: Texture Analyzer Vs. Water Activity

<table>
<thead>
<tr>
<th>Aw</th>
<th>Texture Analyzer-Grams of Force</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.682</td>
<td>135.9</td>
</tr>
<tr>
<td>0.722</td>
<td>83.9</td>
</tr>
<tr>
<td>0.809</td>
<td>40.6</td>
</tr>
</tbody>
</table>

**Figure 12. Enova Oil: Texture Analyzer vs Water Activity**
Experiment 4: Sensory Panel Scorecard Results
**Three trials combined into one pie chart for each paired comparison test.

**Figure 1. Grape Seed Oil Brownies vs. Vegetable Oil Brownies**

Grape Seed: 14  Vegetable: 7
Grape Seed Oil was preferred 50% more than vegetable oil in brownies.

**Figure 2. Vegetable Oil vs. Flaxseed Oil**

Vegetable Oil: 16  Flax Seed: 5
Vegetable Oil was preferred 68% more then flax seed oil brownies.
Figure 3. Vegetable Oil vs. Enova Oil Brownies

Vegetable Oil Brownies were preferred over enova oil brownies by 9% of the sensory panel.

Enova: 10  Vegetable: 11

Figure 4. Grape Seed Oil vs. Enova Oil Brownies

The sensory panel preferred grapeseed oil brownies 68% more than brownies made with enova oil.

Enova Oil: 5  Grape Seed Oil: 16
Grape Seed Oil Brownies are preferred 76% more than flaxseed oil brownies.

Flaxseed: 876
Grape Seed: 754

Figure 5. Grape Seed Oil Brownies vs. Flax Seed

Enova Oil was preferred by the sensory panel 39% more than the Flaxseed oil brownies.

Enova Oil: 13  Flaxseed Oil: 8
Flaxseed: 876
Enova: 207

Figure 6. Enova Oil vs. Flaxseed Oil
IV. Discussion

In this experiment it was found that the replacement of edible oils altered the texture of the brownies which altered the mouth feel and the flavor of the boxed brownies.

Texture was analyzed in experiment 1 to measure the oxidative rancidity of the boxed brownies. In experiment 1 the most moist variable was the control variable made with vegetable oil, sample 312. The control variable was gooey and mushy towards the center of the baking pan. The texture was not comprised by any added or changed ingredients because the normal baking procedures and ingredients were used in this recipe. When compared with grape seed oil, sample 754, the texture was slightly changed. There was 8 grams of difference between the forces it took to puncture the brownie. Grape seed oil contains 46% vitamin E. Vitamin E helps prevent fats from deterioration of lipids that contain carbon-carbon double bonds. To minimize lipid peroxidation essential fatty acid should be taken in with at least 500 mg of Vitamin E per day and a good source of vitamin E comes from grape seed oil. In a study done by M. Balu, it was found that oxidative stress causes ascorbic acid concentration to be considerably reduced in the striatum and the hippocampus where it normally interacts with the neurons within the brain. The results show that grape seed extract is capable of reversing age associated decline of vitamin c. Grape seed is also a membrane bound fat soluble vitamin and is an essential factor in stopping cellular damage from the stress of oxidation. Vitamin E deficiency promotes increase lipid peroxidation which causes cells to be exposed to oxidative damage. (299)

The quality of a food can be determined through its water activity levels and after reaching 0.80 spoilage bacteria can begin to grow. Foods with less that 0.80 Aw values have longer shelf life at the grocery store or market because the low water content stops the growth of microbes. Aw of 0.90 molds and yeasts can begin to grow. The water activity was measured in experiment 2. There was little difference between the between the levels of water activity of the 4 oil variables and the reactions they had in the brownie mix. Figure 8 represents the stable water activity levels of the brownies.
activity levels that ranged from 0.676 to 0.856 Aw. In experiment 3, the texture was compared to the water activity levels in each of the oils. Figure 9 represents a linear relationship between the increase of water activity and increase in grams of force needed for vegetable oil. In comparison figure 10, flax seed oil, figure 11, grape seed oil, and figure 12, Enova™ Oil show an increase in water activity and a decrease in the grams of force. From these results one can conclude that the more water activity there is in the brownie the more tender it is going to be and the less amount of force to take to cut, pierce, or break the brownie.

Experiment 4 was completed by a sensory panel who participated in a paired comparison test. There was a variety of responses by the panel judges. The grape seed oil, sample #754, and the vegetable oil, sample #312 were preferred the most. Because the samples were assigned random numbers and arranges using the randomization method it was difficult for the taste panel to determine which sample was the control sample. In figure 3 it is obvious that the panelists had a difficult time deciphering the difference between Enova™ Oil brownies and vegetable oil brownies. There was a 9% preference for sample 312, which proves that replacing vegetable oil with a Diacylglycerol (DAG) does not compromise the flavor of the brownies. DAG is a dietary oil that contains mainly 1; 3-DAG reduces body fat accumulation in humans as compared to triacylglycerol (TAG) oil (Taguchi, 380). In figure 1 when comparing brownies made with grape seed oil and brownies made with grape seed oil, 50% of the panelists chose the grape seed oil brownie. As in other comparisons, sample 754 was strongly preferred over the other samples. The 754 sample was often described as the product with the best mouth feel, texture, and moistness. In every comparison made the flaxseed oil was not the favored product. The flaxseed oil that contained fish oils and large amounts of omega 3 fatty acids left a fishy aftertaste the panelists did not enjoy. The texture of the flaxseed oil brownies was dense. Referring back to figure 1 the flaxseed oil had one of the toughest textures because it required the most grams of
force even at the optimum water activity levels. The fat in flax seed oil is monounsaturated and in the other oils most of the fats are polyunsaturated. Flax seed oil has less carbon chains to break down and can be absorbed and broken down faster but its flavor is compromised for this fast metabolic rate.

Replacing the oil source in the brownies affected the flavor components, and texture components of the brownies. The oxidation and the different sources of the fatty acids in the carbon chains changed the texture slightly but because of their added health benefits it is more appropriate for the future of America’s health. Fats are essential to the baking process because they contribute to the way they look, taste, and feel as they melt in your mouth while increasing the fullness consumers feel during the meal. (Akoh, 47) By using oils like flax seed oil, grape seed oil, and Enova™ Oil the nutrient intake can increase and the absorption levels of fat can decrease while still maintaining a great tasting brownie you can eat without feeling guilty.
V. References


Blameless Brownies

Investigating the replacement of fats in commercially prepared brownies

Emma Preuschl
Dr. James Daniels
Food Chemistry 453
Individual Project